

FIELD CAMPAIGNS AND AIR QUALITY MONITORING – PART 2

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WASCAL Course 608 – Part 2 – 19 June 17



TALK OUTLINES

- Science & Species: Air Quality Basics – [Part 1 \(15/6/17\)](#)
 - Key Species
 - Scientific Issues that motivate campaigns
- Monitoring from Space - [Part 1](#)
 - NO₂ – Decadal changes, environmental “success tale”
 - Ozone – Challenge and Status in tropical troposphere
 - HCHO- see Prof Marais’ Talk
- **AQ Data & Field Campaigns – TODAY’S TALK**
 - **More about SHADOZ network, Quality Assurance, Satellite data evaluation with TTOR**
 - **Why & How Campaigns. Data analysis. Example: KORUS-AQ, May-June 2016**
 - **Follow-up - Hands-on, Work with data**

RECALL LAST LECTURE ON TROPOSPHERIC O₃ SATELLITE PRODUCTS AND SONDE DATA

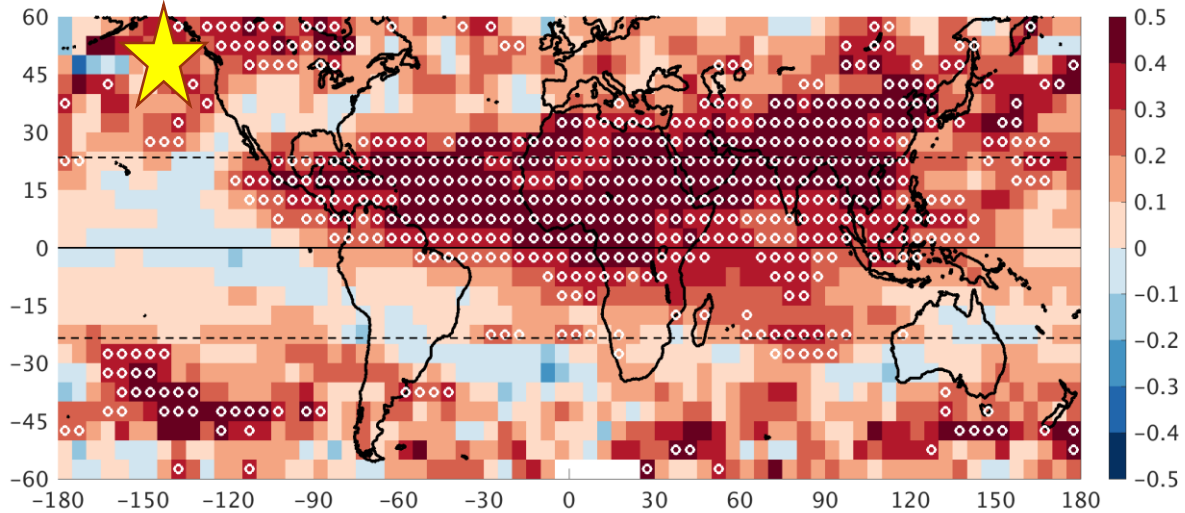
- Monthly maps of column O₃ amounts useful in tropics for studying interannual variability but different products diverge widely (TOAR Assessment to evaluate. Stay tuned)
- Ozonesondes in tropics are limited to SHADOZ (<http://tropo.gsfc.nasa.gov/shadoz>). Vital for satellite validation. 19-yr data record is available for study of climatology and interannual variability.
- Present more on SHADOZ and Quality Checks. Based on al. (*JGR*, 2012) & Thompson et al. (in preparation, 2017)
- **Assignment for YOU. Work with SHADOZ data from equatorial African stations, AERONET, meteo. observations, eg precipitation; model re-analyses**



OMI-MLS TRENDS

(OWEN COOPER ET AL.). IGAC/TOAR REPORT, 2017

OMI/MLS tropospheric column ozone, 2005–2015 Months: 6 7 8



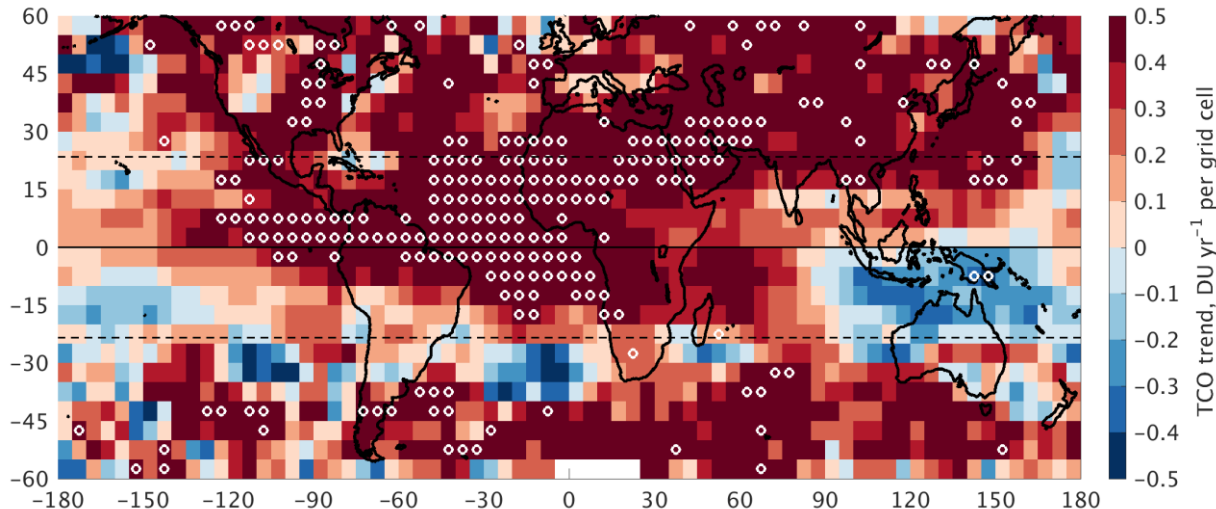
2005–2015 (JJA)

White dots indicate statistically significant trend

Zhang et al, *Nature-Geoscience*, 2016

CAVEAT! SONDES DISPLAY NO O₃ INCREASES IN CANADA

OMI/MLS tropospheric column ozone, 2008–2013 Months: 6 7 8



2008–2013 (JJA)

To match IASI record In Wespes et al., ACP, 2016.



WHY, WHERE, HOW: SHADOZ START IN 1998. 2017: > 7000 PROFILES

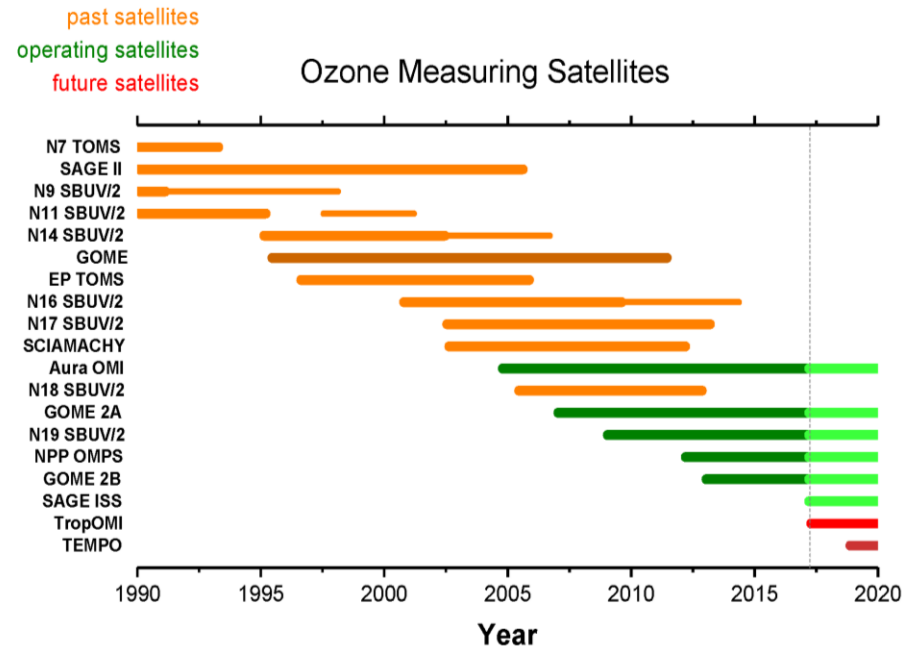


- “Strategic” ozonesonde network coordinates launches in space & time for specific scientific purposes
- **Satellite Requirements:** Validate O₃ profiles from TOMS/ UARS/SBUV (90s), ENVISAT, Aura, NPP, MetOp (2000->)
- **Scientific Needs:** Where does total ozone wave-one originate – in stratosphere or troposphere? => *Requires zonal coverage of stations.* **PRACTICAL CONSTRAINTS**
 - **Operational – host supplies ground stations, launch gas, personnel**
 - **NASA, NOAA supply *some* sondes – ALL data archived @ GSFC**
 - **Data distribution: open, timely, user-friendly format**
 - **Leveraging resources has led to sustained network success**

SHADOZ Sites, URL=<http://croc.gsfc.nasa.gov/shadoz>



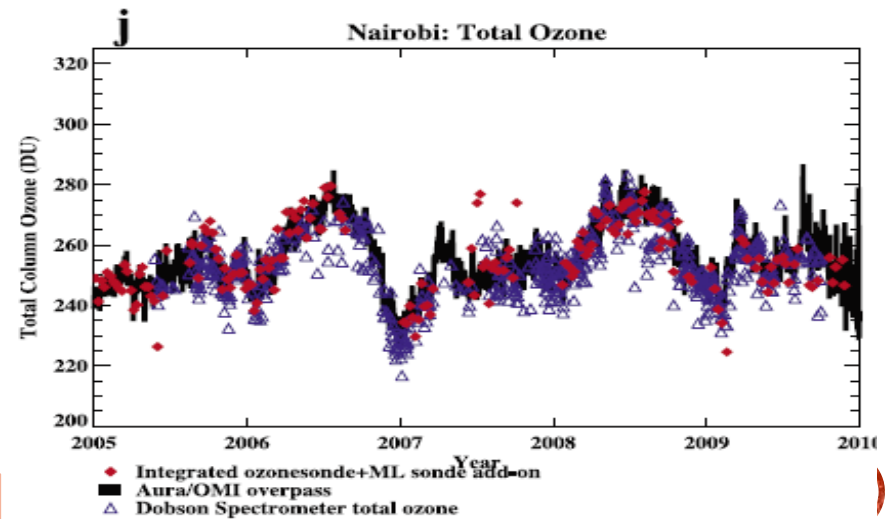
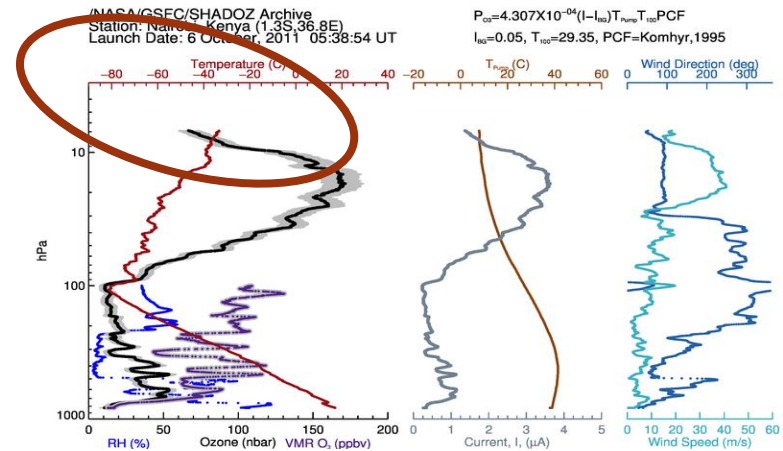
“Tropical Stations,” 10 at < 19deg lat



SHADOZ QUALITY ASSURANCE: COMPARE SATELLITE OVERPASS & GROUND-BASED INSTRUMENT TOTAL OZONE COLUMNS



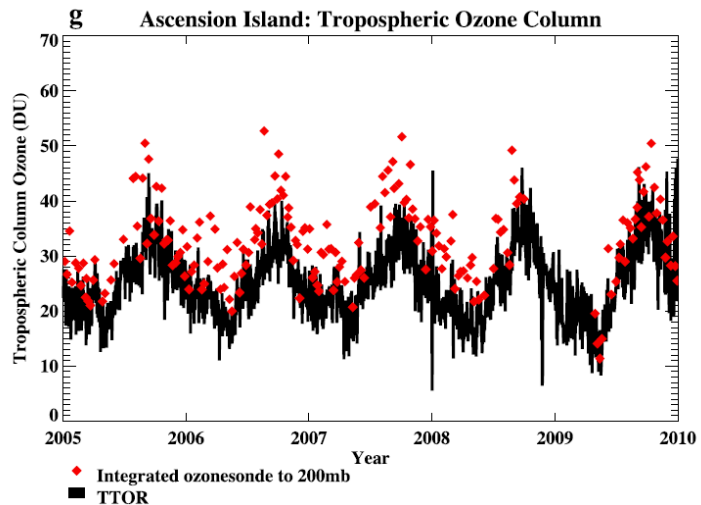
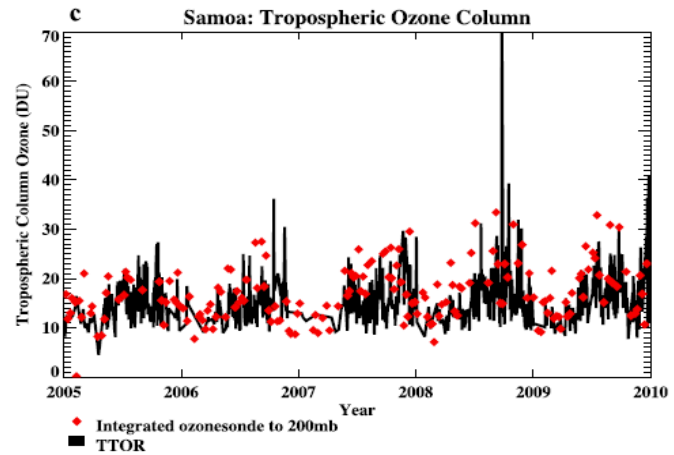
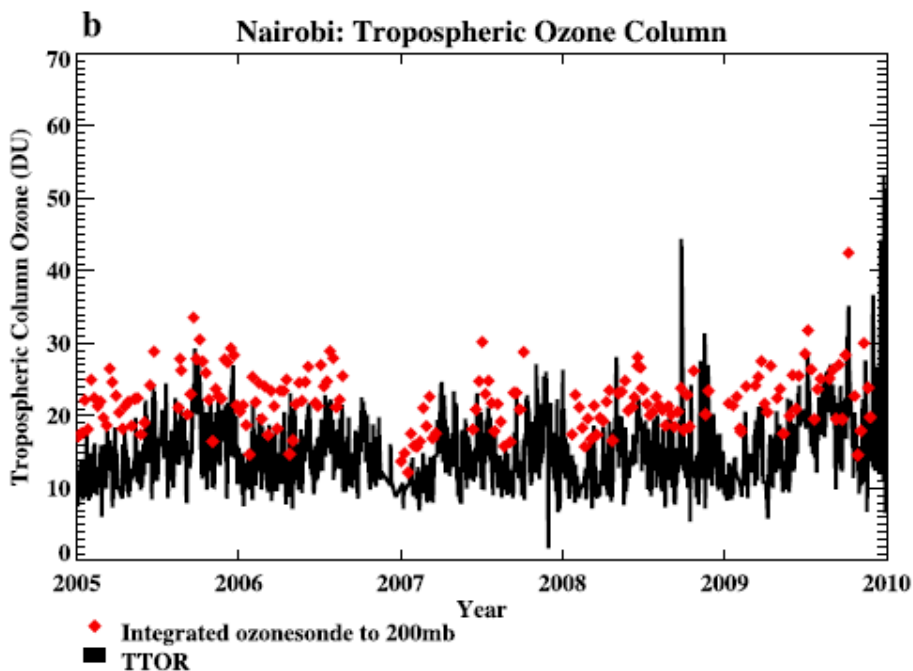
- Total column ozone from satellites in TOMS (1998-2004), OMI (2005-present), OMPS (2011-present) carefully calibrated with global ground-based spectrometers
- For sondes extrapolate ozone above burst to compute total O₃
- Example. Nairobi sonde (Upper)
 - Total ozone with OMI (2005-2009), five-yrs, with Dobson, agree within 1%! (Lower)
 - => Confident in using Nairobi data to evaluate tropospheric ozone TTOR product (Next)



Thompson

Thompson et al, 2012

TROPOSPHERIC “TTOR” PRODUCTS – AVERAGE 20-25% LOW, DO NOT CAPTURE RANGE OF VARIABILITY



SHADOZ:
<http://tropo.gsfc.nasa.gov/shadoz>

Thompson et al, 2012



CAMPAIGNS: WHY, HOW, WHEN, WHERE THEY ARE CONDUCTED?

- Satellites give global view but tend to be too coarse in horizontally & vertically to resolve structure. Poor near-surface viewing, limited numbers of species
- **Goals of Field Campaigns:**
 - **Validate** evolving satellite products
 - Measure many species and **processes**, e.g. meteorological parameters radar, winds, boundary-layer height
 - **Analyze data** & relationships to **test hypotheses** about processes
 - Further analyze with **models to answer process questions quantitatively**. Test theories, evaluate models, sources (refer to Marais talks)

WHY, HOW, WHEN, WHERE OF MODEL FIELD CAMPAIGN: KORUS-AQ **



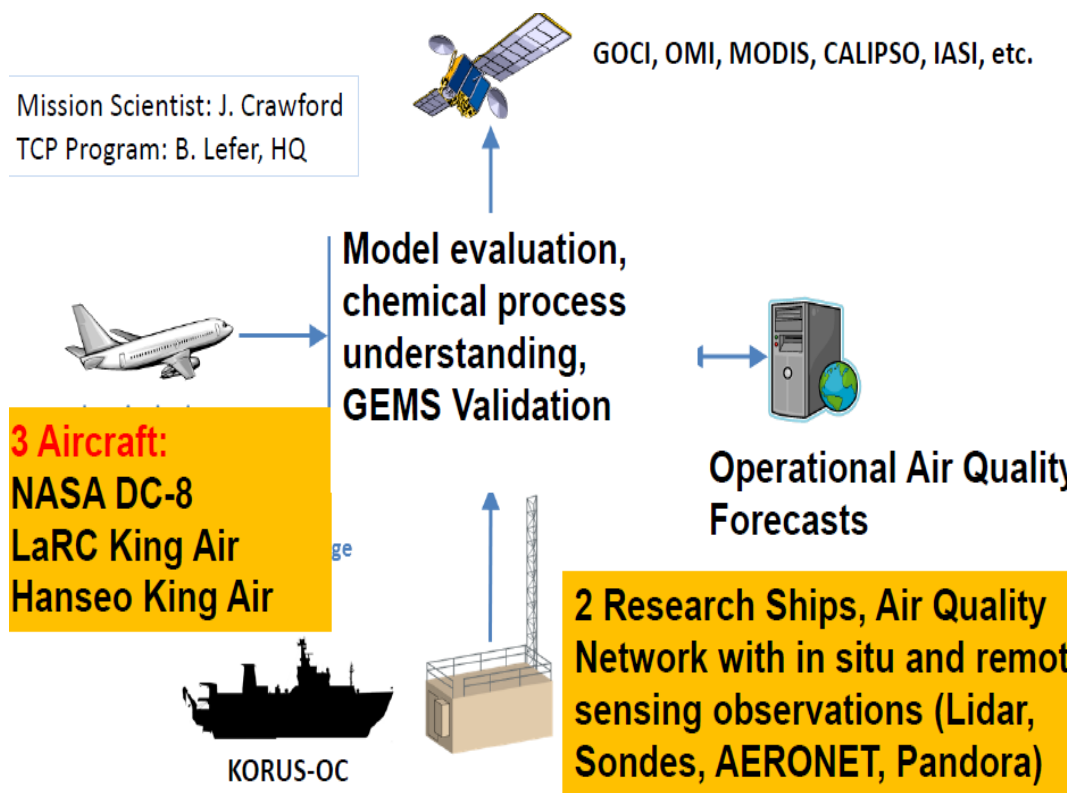
- Joint Korea-US (KORUS) campaign, May-June 2016 in ROK
- Prepare for GEMS geo-stationary Korean satellite (2019) with prototype field campaign
- Integrate aircraft, ground-based, satellite data with models
- Study existing data to prepare **WHITE PAPER** with scientific needs, justification, concept and strategies.
- White Paper is “open for comments” and multiple groups may contribute, decide to join

▪ espo.nasa.gov/home/korus-aq/content/KORUS-AQ

Thompson *** THREE AFRICA CAMPAIGNS: SAFARI-92/TRACE-A. JGR, 1996; SAFARI-2000. JGR, 2003; SAFARI-2000; AMMA (West Africa) ACP papers. ORACLES – 2016-2019

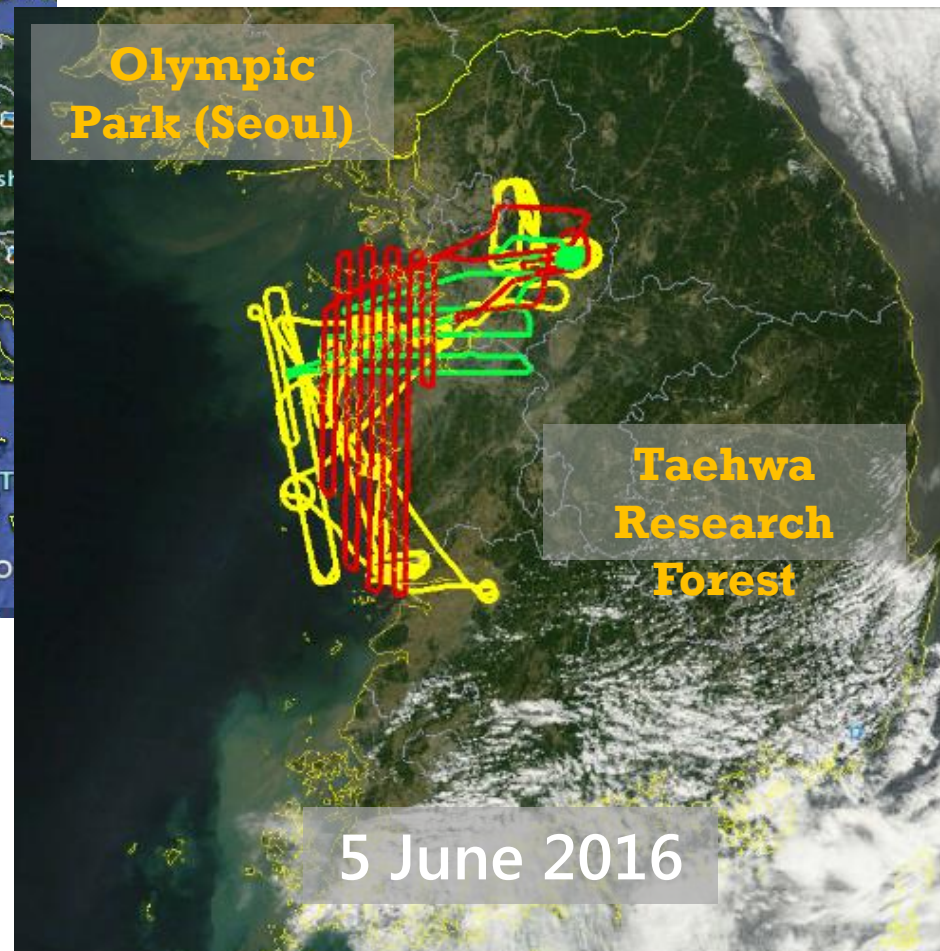
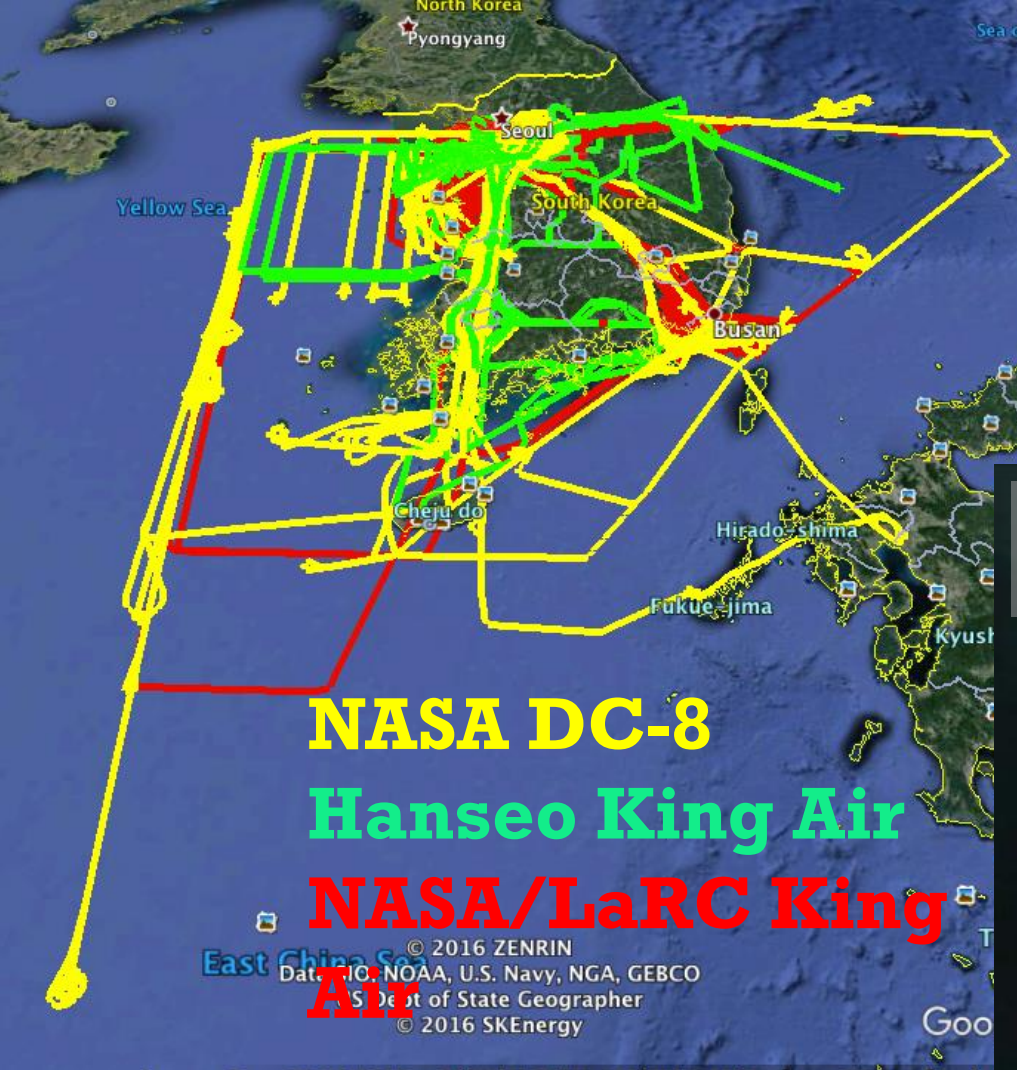
MOTIVATIONS & APPROACH FOR KORUS-AQ

- Scientific Goals & Questions**
 - Collect many vertical profiles of ozone, HCHO, NO₂ for statistics on geo-stationary satellite
 - Compare ground & aircraft measurements
 - What are main ozone and PM processes?
 - Is Seoul area pollution predominantly local or from elsewhere (China)?
 - Mix Korean & US instruments, aircraft & researchers



FLIGHT TRACKS

- Entire Campaign (**Left** – 22 flight days)
- Ground-sites near Seoul (below)



NASA DC-8: In-situ and remote-sensing trace gas, aerosol, met. instrumentation

Hanseo Univ. King Air: In-situ trace gases

NASA King Air: Geo-TASO and MOS (ocean color, atmospheric correction)

KORUS-AQ SAMPLE FINDINGS

- Korean air very dirty!
- Koreans have many sources of VOC, Nox
- New VOC, HCHO instruments reveal evolution of pollution
- Tracers and trajectories point to both China and strong Korean sources!
- New NASA instruments – Pandora, Ozone Lidar – collect useful data.

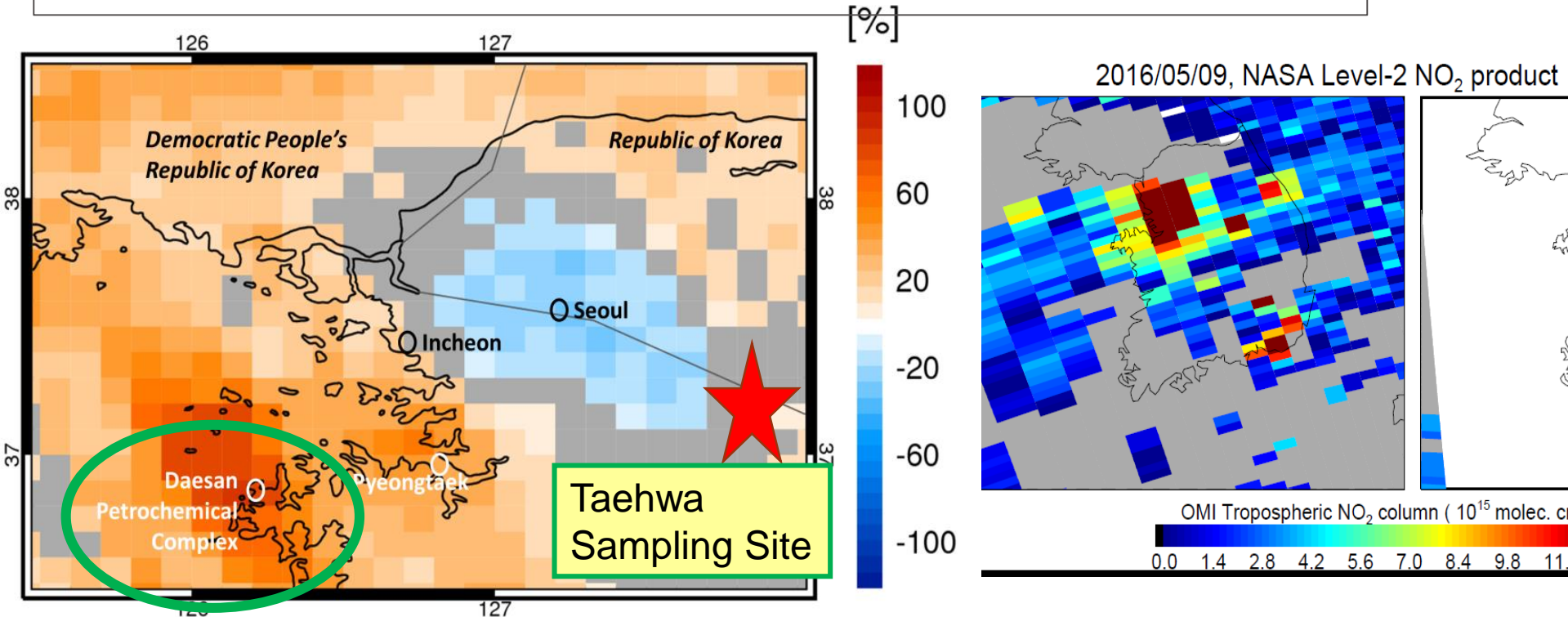


Rural,
Resort
Area,
Konjiam

Below
Fast-
Growing
city



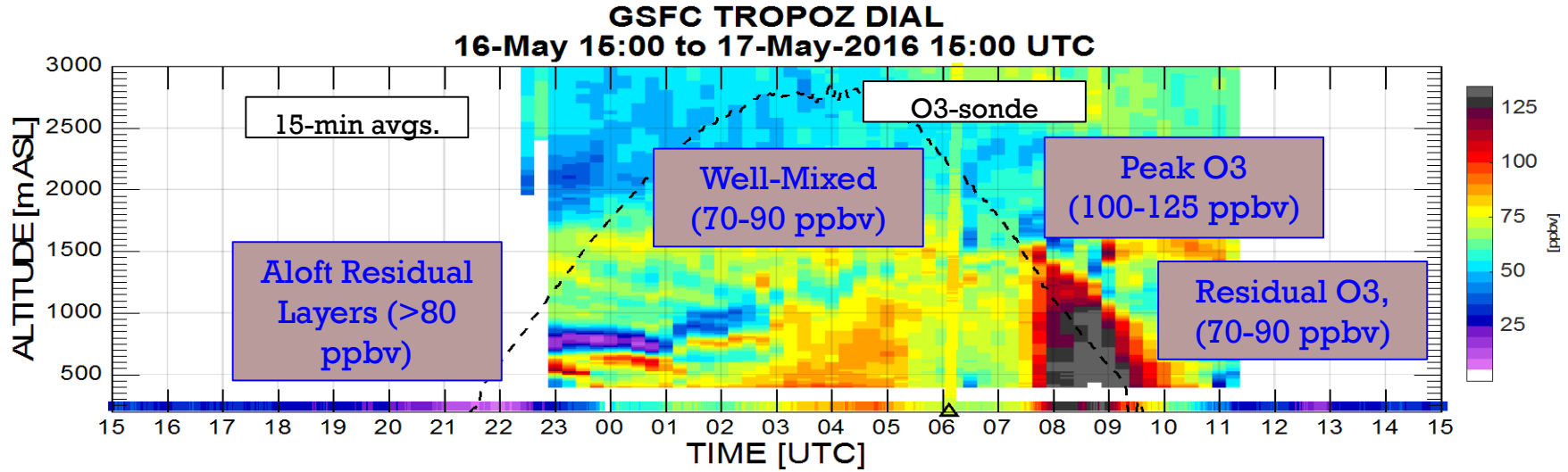
BACKGROUND CLIMATOLOGY & MAY 2016 SAMPLE OF OMI NO₂



Δ OMI NO₂ (%): 2005-2014 Seoul, Busan, 9/5/16
High NO₂ – Korean cities

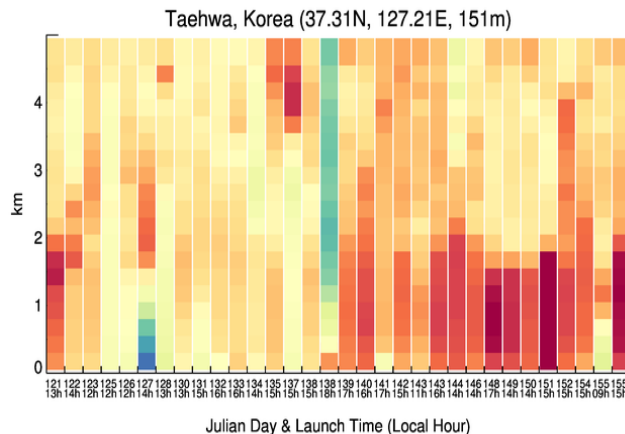
KORUS-AQ EXPERIMENT, KOREA, MAY 2016

GSFC TEAM: TAEHWA FOREST, 30 KM E OF SEOUL



Surface O₃
75-110 ppbv

O₃ > 2x
Maryland
(DC) O₃
In 2011



**ASA/GSFC/AMThompson/KORUS-AQ/Y2016



Typical
Afternoon
Haze,
Taehwa
Research
Forest

MEASURING NO₂ @ TAEHWA. IN-SITU AND PANDORA SPECTROMETER

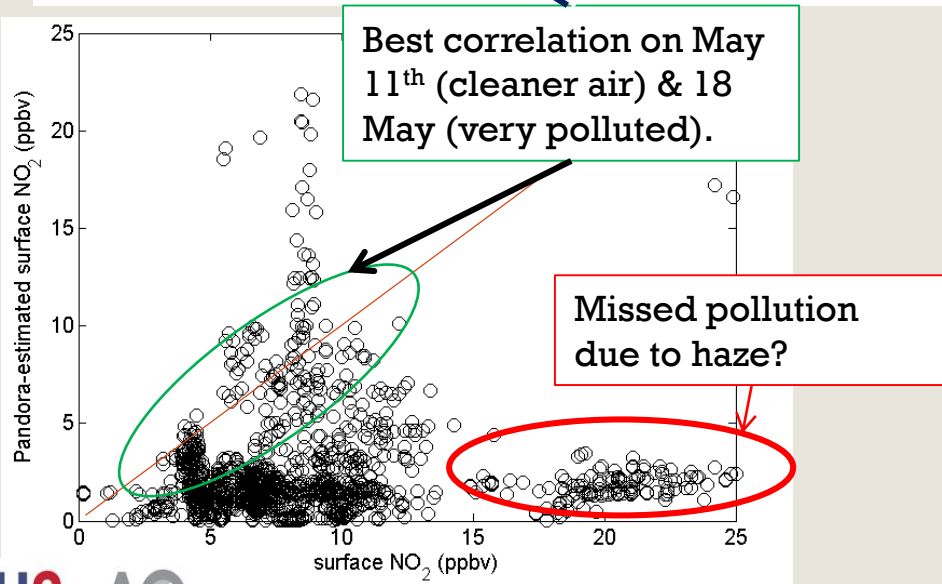
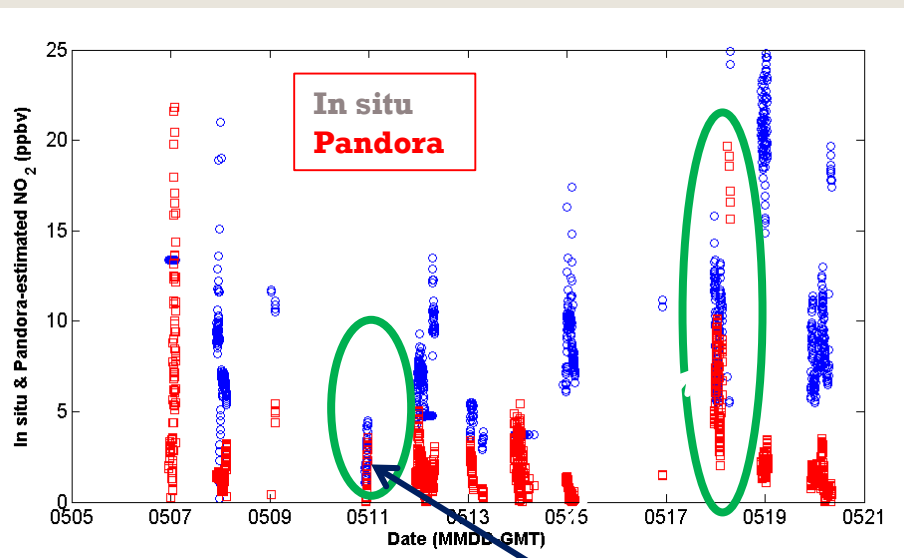


Sondes next to Trailer with Lidar, In-situ ozone, NO₂ instruments



Pandora at Taehwa!
Nader Abuhassan, Pandora Engineer

EVALUATION OF IN SITU & PANDORA-ESTIMATED SURFACE NO₂?

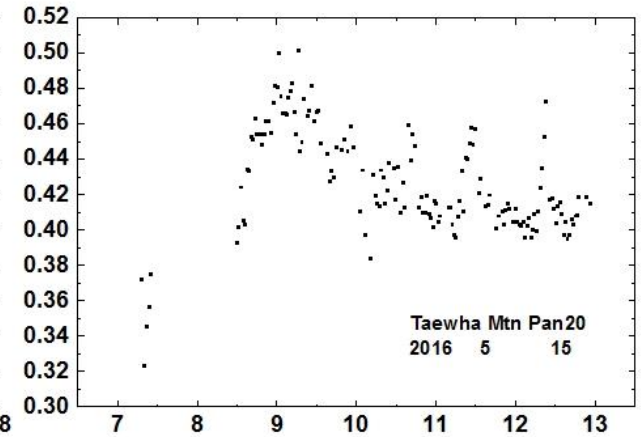
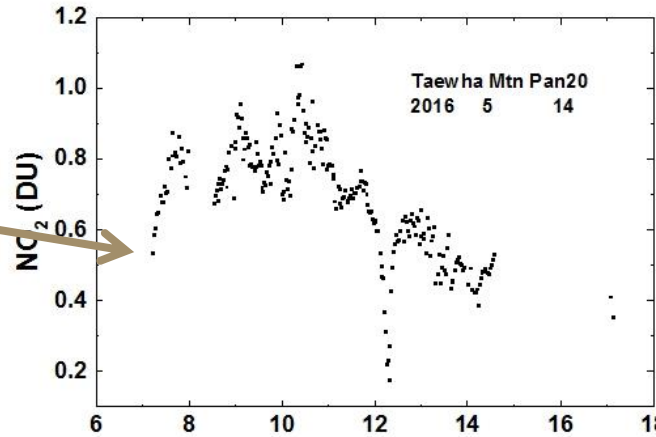


- Why do several days after 14 May show too-low Pandora surface NO₂?
- Best guess is the interference of aerosols and clouds, which affects the Pandora retrieval.
- Looking at one particular case on 14/15 May, the method does not work in high-aerosol conditions.

RESULTS #3: WHY DO SOME DAYS HAVE 10+ PPBV IN- SITU & PANDORA-ESTIMATED SURFACE NO₂ DIFFERENCES

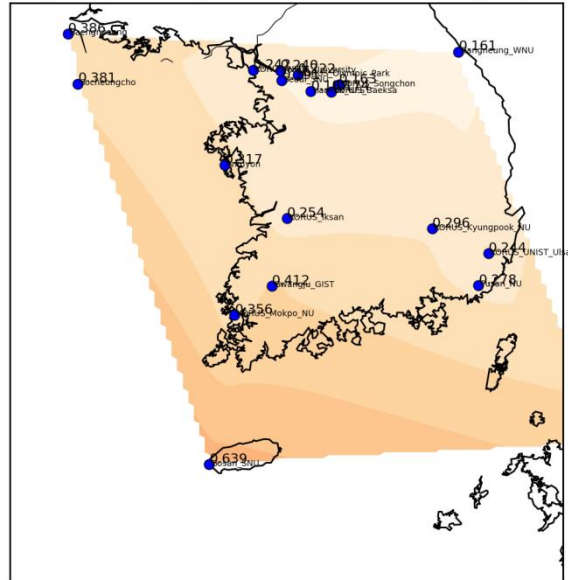
Diurnal NO₂ columns (in Local Time) courtesy of Jay Herman.

Drop in NO₂ column abundance from May 14th to 15th.

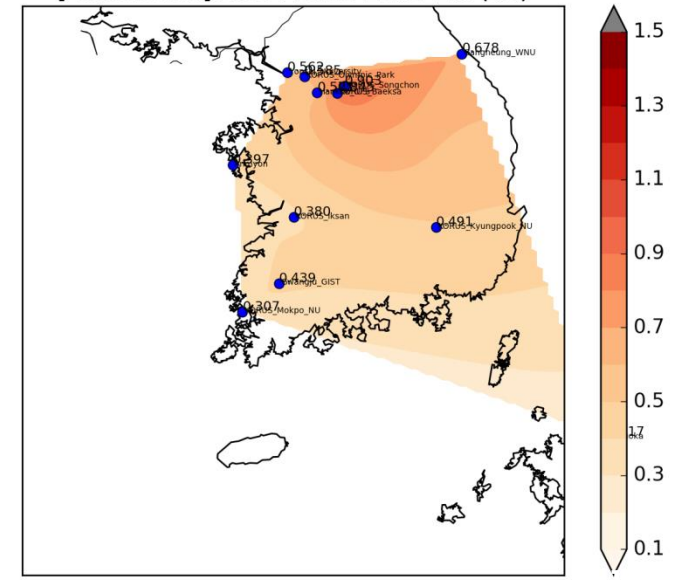


AERONET DRAGON KORUS-AQ AOD from May 14th/15th shows increase in particles over Taehwa.

[2016.05.14] AOD440nm Level 1.5 (V3)

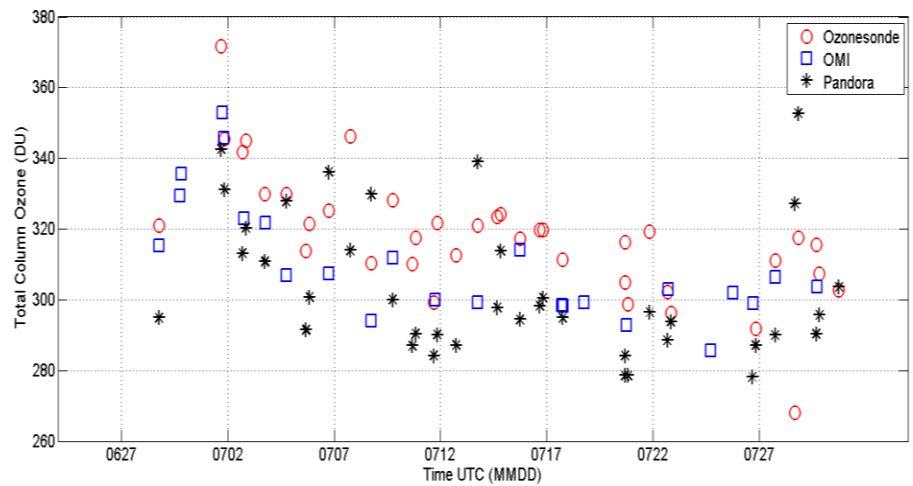
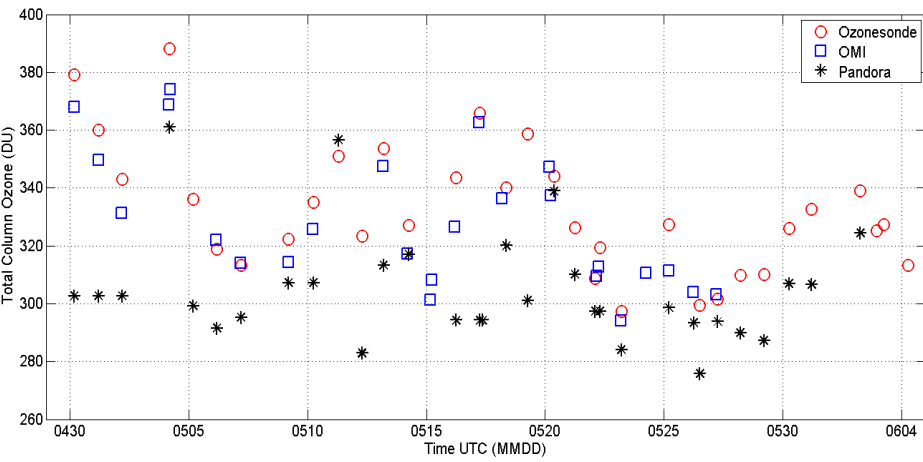


[2016.05.15] AOD440nm Level 1.5 (V3)





MEASURING O₃ @ TAEHWA. IN-SITU, OMI AND PANDORA SPECTROMETER. COMPARE TO MARYLAND (2011) CAMPAIGN, WHICH IS BETTER (FEWER AEROSOLS?)



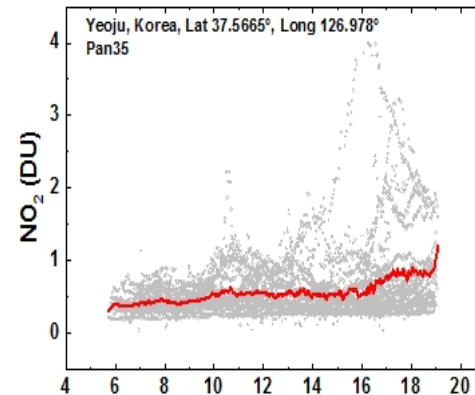
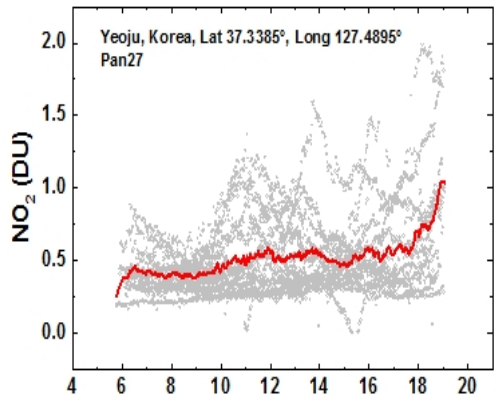
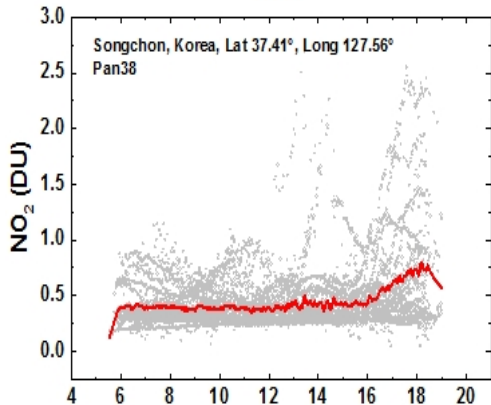
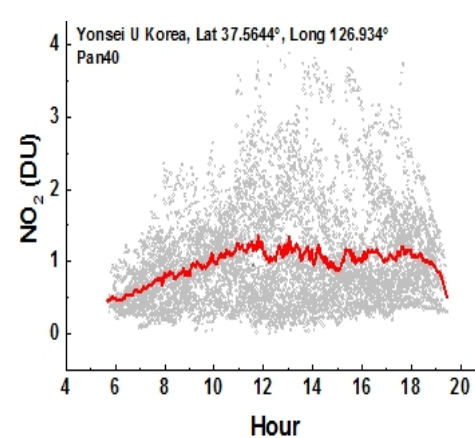
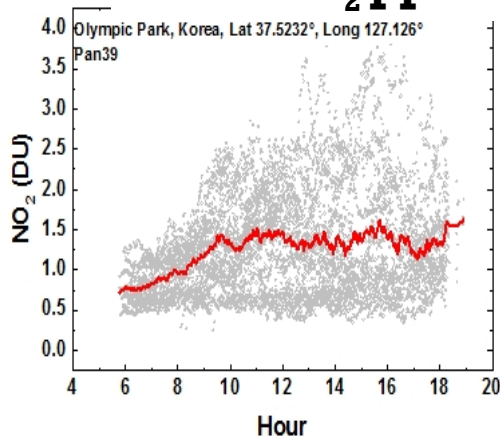
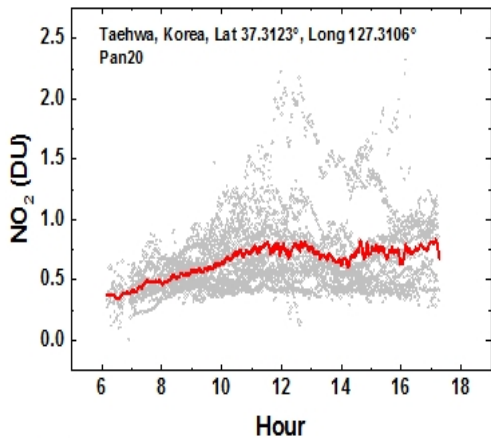
Instru.	Median (DU)	Mean (DU)	Std (DU)
Sonde	332	334	21
OMI	322	328	23
Pand.	300	305	19

Instru.	Median (DU)	Mean (DU)	Std (DU)
Sonde	318	318	18
OMI	305	310	18
Pand.	296	303	20

PANDORA SUMMARY OF 6 SITES IN KORUS-AQ. NOTE SCALE RANGES

Seoul - OLY & Yonsei – surface 20-30 NO₂ ppbv

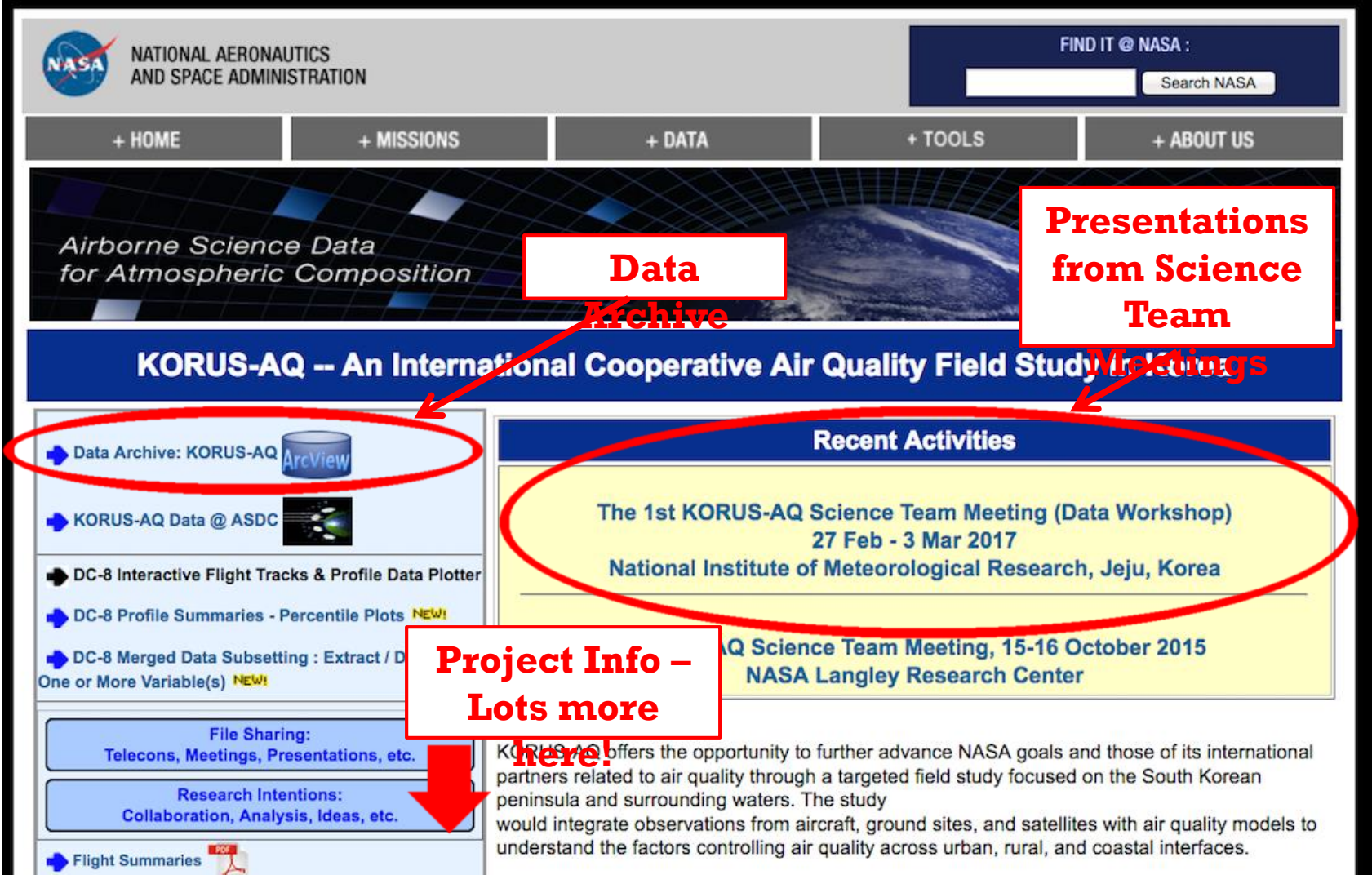
Taehwa
Sondes-
TROPOZ
Lidar Site



Cleaner, like
GSFC, 2-3 x
less than Seoul
J. R. Herman

DATA ACCESS EXAMPLE:

Archive Homepage: <https://www-air.larc.nasa.gov/missions/korus-aq/>



The screenshot shows the NASA website for the KORUS-AQ mission. At the top left is the NASA logo and the text "NATIONAL AERONAUTICS AND SPACE ADMINISTRATION". To the right is a search bar labeled "FIND IT @ NASA :". Below this is a navigation menu with buttons for "+ HOME", "+ MISSIONS", "+ DATA", "+ TOOLS", and "+ ABOUT US". The main banner features the text "Airborne Science Data for Atmospheric Composition" and "KORUS-AQ -- An International Cooperative Air Quality Field Study".

Red annotations highlight specific areas:

- A red box labeled "Data Archive" points to the "Data Archive: KORUS-AQ" link in the left sidebar, which is also circled in red.
- A red box labeled "Presentations from Science Team Meetings" points to the "Recent Activities" section, which is also circled in red. This section lists "The 1st KORUS-AQ Science Team Meeting (Data Workshop) 27 Feb - 3 Mar 2017 National Institute of Meteorological Research, Jeju, Korea" and "KORUS-AQ Science Team Meeting, 15-16 October 2015 NASA Langley Research Center".
- A red box labeled "Project Info - Lots more here!" points to the "Research Intentions: Collaboration, Analysis, Ideas, etc." section in the bottom left.

HOW TO WORK WITH FIELD DATA? USE WEB ARCHIVES. ALL DATA FROM NASA EXPERIMENTS IS OPEN!



Archive Homepage: <https://www-air.larc.nasa.gov/missions/korus-aq/>

Data Archive

Project Info - Lots more here!

Relevant Data / Links

>> Satellite AOD Data during KORUS-AQ

- ➔ GOCI_YAER_V2 AOD Data
- ➔ GOCI_YAER_V2 with_AHlclد_KORUSAQ_period
- ➔ MI AOD data
- ➔ AHI AOPs data

These datasets are available via anonymous FTP

➔ KORUS-AQ Data Management

➔ ICARTT Data Format Document

➔ Flight Profile Summary

➔ Flight Summaries PDF

➔ Flight Tracks KMZ Files

DC-8 | UC-12 | Hanseo

➔ Forecast Products ...

➔ Satellite Observations ...

➔ Real-time Surface Observations ...

➔ PANDORA Data

➔ Data Archive: KORUS-AQ ArcView

➔ KORUS-AQ Data @ ASDC

➔ DC-8 Interactive Flight Tracks & Profile Data Plotter

➔ DC-8 Profile Summaries - Percentile Plots

➔ DC-8 Merged Data Subsetting : Extract / D One or More Variable(s) **NEW!**

File Sharing: Telecons, Meetings, Presentations, etc.

Research Intentions: Collaboration, Analysis, Ideas, etc.

➔ Flight Summaries PDF

NASA NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

+ HOME + MISSIONS + DATA

Airborne Science Data for Atmospheric Composition

KORUS-AQ -- An International Cooperative Air Quality Science

The 1st KORUS-AQ National Institute of Environmental Health and Safety

➔ Flight Summaries PDF

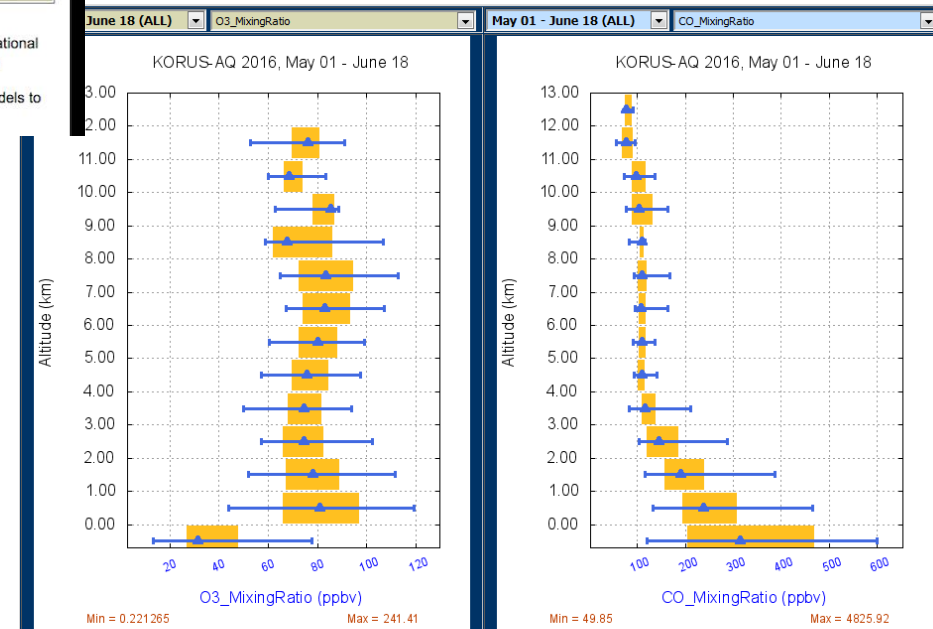
DATA ACCESS EXAMPLE:



Wealth of information on homepage including aircraft flight summaries, "quick look" plots from archived data, and links to outside sources of data and model output

KORUS-AQ DC-8 Profile Summaries

Percentiles: May 01 - June 18, 2016 (R2)



Example quick look of O₃ and CO measurements from the DC-8

Technical project details, White Papers, instrumentation, and participant lists are also found via this website



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Airborne Science Data
for Atmospheric Composition

KORUS-AQ – An International Cooperative Air Quality Field Study in Korea

- Data Archive: KORUS-AQ
- KORUS-AQ Data @ ASDC
- DC-8 Interactive Flight Tracks & Profile Data Plotter
- DC-8 Profile Summaries - Percentile Plots **NEW!**
- DC-8 Merged Data Subsetting : Extract / Download One or More Variable(s) **NEW!**

Recent Activities

The 1st KORUS-AQ Science Team Meeting (Data Workshop)
27 Feb - 3 Mar 2017
National Institute of Meteorological Research, Jeju, Korea

KORUS-AQ Science Team Meeting, 15-16 October 2015
NASA Langley Research Center

File Sharing:
Telecons, Meetings, Presentations, etc.

Research Intentions:
Collaboration, Analysis, Ideas, etc.

Flight Summaries

KORUS-AQ offers the opportunity to further advance NASA goals and those of its international partners related to air quality through a targeted field study focused on the South Korean peninsula and surrounding waters. The study would integrate observations from aircraft, ground sites, and satellites with air quality models to understand the factors controlling air quality across urban, rural, and coastal interfaces.

DATA ACCESS EXAMPLE:

NASA NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

[+ Visit NASA.gov](#)
[+ Contact NASA](#)

Airborne Science Data for Atmospheric Composition

Home Tools Missions Data Contact Us

Login here to enable HTTP download
User ID:
Password: Login

KORUSAQ_2016
Current Archive Status
As of Wed Mar 22 12:53:27 2017 EST

Platforms/Sites

DC-8 Aircraft	B200 Aircraft	Hanseon King Air	>> R/V Onnuri Ship	R/V Jang Mok Ship
Merges	Analysis	Sondes	Trajectory	Model
NIER Mt. Taehwa *	NIER Olympic Park *	NIER Bulkwang *	NIER Bangi *	NIER Bangnyung *
NIER Daejeon *	NIER Gwangju *	NIER Ulsan *	NIER Jeju *	Fukue *
Anmyeon *	Busan *	Seoul-Yonsei Univ. *	Songchon *	Yeoju *
Ground-Other	All Others			

Data sets from selected platform, sorted by PI

* Ground Site

Current list for the RV ONNURI SHIP Data:

PI Directory	Last Updated	Parameters	Research Description (KORUSAQ)
JORDAN.CAROLYN/	Mar 17, 2017	+ Show VarList	
THOMPSON.ANNE/	Mar 21, 2017	+ Show VarList	Surface in-situ O3, NO/NOy, NO2, CO measurements
TZORTZIOU.MARIA/	Mar 22, 2017	+ Show VarList	Column aerosol measurements from the MicroTops II Sunphotometer

[JORDAN.CAROLYN/](#)

Filename	Recv'd/Updated	Size (KB)
korusaq-TAP-Abs-APNeph-Scatt_SHIP-ONNURI_20160520_R0.ict	20170317	4907.3

Data Archive Direct Link: <https://www-air.larc.nasa.gov/cgi-bin/ArcView/korusaq>

Tabs to navigate to instrument platforms/ground sites and PI data sets

Standard text file formats (ICARTT)

SUMMARY: AQ MONITORING & RELATED FIELD CAMPAIGNS

- Many trace species, gases & particles, are monitored by satellite, eg. NO₂ “trends and changes”
 - Only space view tracks global change, intercontinental transport
 - Limitations in remote sensing of “nose level” pollution necessitate surface and ground-based monitoring
- Field Campaigns are assembled to answer specific questions about processes making pollution, transport & sources
 - Aircraft payloads & flights, monitoring & campaign ground sites are operated for synergistic observations
 - Models are used for flight forecasts and data integration, interpretation

LOOKING AHEAD!! ACKNOWLEDGMENTS

- **What are the BIG questions about pollution in West Africa?**
- **How does atmospheric composition over West Africa connect to changes in land-use, biosphere, water cycle & climate?**
- **PUT YOUR ANALYSES TOGETHER TO BEGIN WHITE PAPER FOR WEST AFRICAN FIELD CAMPAIGN. *Study meteo. Climatology, aerosol, trace gas climatology, ie seasonality & interannual variability. Use satellite and ground data***
- **Thanks: NASA, NOAA. WASCAL!!!!**
- B. N. Duncan, L. Lamsal, A. M. Thompson et al. A space-based, high-resolution view of notable changes in urban NO_x pollution around the world (2005–2014), *JGR*, 121, doi: 10.1002/2015JD024121, 2016.
- B. N. Duncan et al: “Satellite data of atmospheric pollution...” dx.doi.org/10.1016/j.atmosenv.2014.05.061
- N. A. Krotkov et al., *Atmos. Chem. Phys.*, 16, 4605-4629, doi:10.5194/acp-16-4605-2016, 2016
- A. M. Thompson et al., *JGR*, 117, D23301, doi: 10.1029/2010JD016911, 2012.
- A. M. Thompson et al, *J. Atmos. Chem.*, DOI 10.1007/s10874-014-9283-z, 2014
- Y. Zhang, O. R. Cooper, A. Gaudel, S-Y. Ogino, P. Nedelec, A. M. Thompson, J. J. West, Equatorward redistribution of emissions dominates the 1980 to 2010 tropospheric ozone change, *Nature-Geoscience*, DOI: 10.1038/NGEO282, 2016.

EXTRAS

TROPOSPHERIC OZONE COLUMN AMOUNT – DATA SOURCES

“Tropospheric ozone satellite” Products, mostly TOMS or OMI-based, are not ideal but may be usable for exploratory studies.



https://acd-ext.gsfc.nasa.gov/Data_services/cloud_slice/

Monthly maps, some software for Trends analysis

DATA: OMI/MLS tropospheric ozone (original product)

DATA: GMAO assimilated OMI/MLS tropospheric ozone profile product

MOVIES: Global tropospheric ozone movies from OMI/MLS showing the large year-round wave-one pattern in the tropics (maximum in the Atlantic), NH extra-tropical maximum around June-August (including the Mediterranean "crossroads" peak region) and SH extra-tropical maximum around September-November